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AND ABSTRACT OF THE LITERATURE

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Disease and the Workmen's Compensation Act

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DISEASE AND THE WORKMEN'S COMPENSATION ACT*

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INTRODUCTION

AS ONE of the specialist medical referees appointed by the Home Office under the Workmen's Compensation Act for the purpose of deciding disputes between employer and employee on questions of medical fact, I have had an opportunity during a period of thirteen years of studying the Workmen's Compensation Act in its relation to industrial disease.

The experience that I have had is of a twofold nature: First, cases are referred to me under the ordinary procedure of the Act, which I will detail a little more fully later on, and are examined in my own consulting room or, in a few instances, in the patient's own home or possibly in a hospital, when the patient is too ill to come to my house. I should like to say at once that in all the cases in which I have been obliged to attend either at a hospital or at the patient's own house I have always met with the utmost courtesy and been afforded every facility for the purposes of my examination.

The second portion of my duties has been from time to time to sit with the judge in the county court and act as assessor in cases in which medical questions were expected to arise upon which the judge wished to have expert assistance. Fortunately for the medical referee these cases are not so numerous as those referred to me for a decision, as they take an inordinate amount of time and the fees allowed by the Home Office are by no means generous or even adequate.

With regard to the county court

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cases in which I have sat as assessor, one governing case is frequently cited, the case of *Bedford* v. *Cowlan & Sons, Ltd.*, Butterworth 9. p. 208. This most important and far-reaching decision was made by the court of appeal. Briefly the case was this: The workman was alleged to have suffered from lead poisoning. The certifying surgeon certified that he was so suffering and the man received compensation for a time. Then it was discovered by a further medical examination that this was not a case of lead poisoning, in fact, never had been a case of lead poisoning, but was a case of paralysis agitans, and that the symptoms of the disease had been in existence before the alleged happening of the accident. No appeal against the certifying surgeon's certificate had been lodged within the statutory period and it was therefore held that this was, by consent, a case of lead poisoning and that the compensation must therefore continue as if it had in fact been a case of lead poisoning. Alteration in the original decision could be obtained only in the event that it was possible to show that the symptoms from which the individual was suffering at the later period were different from those from which he suffered when he was alleged to be suffering from the disease for which he was certified. And thus the law stands at the present moment. The original diagnosis may have been incorrect, but if no appeal is made against the original certifying surgeon's certificate within the statutory period, no review of the case is likely to succeed so long as any of the original symptoms which were present at the time of certification are still present at the time of the review. This particular case has governed several cases in which I have sat as assessor: if the judge has found, as laid down by the court of appeal, that symptoms in existence at the review were in existence at the time of certification, no alteration in the original award could be made.

It would appear to me as a medical man that it is a little unfortunate that a mistaken diagnosis should for all time be maintained as correct because of the failure to carry out the statutory procedure.

My general experience of county court procedure is that in any question of doubt where there is a clash in medical evidence the judge has always been advised by his assessor on the medical points of the expert evidence, and I have never found myself in disagreement with the judgment delivered by his honor.

Procedure under Workmen's Compensation Act

The Workmen's Compensation Act of 1906 provided for the payment of compensation for certain industrial diseases as well as for accidents, and in the third schedule of the Act were cited "the industrial diseases and the process in which they arise" and the onset of the diseases was defined as "the happening of the accident." The industrial diseases to which the Act referred have been added to from time to time and now include thirty different diseases. These thirty diseases cover a wide range of occupation, but the statistics of the Compensation Act published annually show that four main groups account for the bulk of the cases—*i.e.*, miners'

nystagmus; beat hand, knee, elbow, and wrist; lead poisoning; and dermatitis.

For the purpose of applying the Act certain medical machinery was set up which, however, does not apply to cases of accidental injury. The certifying surgeon appointed under the Factory and Workshops Act, 1901, was made the certifying surgeon for industrial disease. Before, therefore, any case of industrial disease comes within the provisions of the Act it must be certified on the proper form by the certifying surgeon of the district, and no other practitioner's certificate is valid, with two exceptions: (1) that the workman is suspended (by a surgeon "appointed" for the particular factory) from his employment on account of having contracted an industrial disease; or (2) that the death of the workman is caused by such disease. The date of the happening of the accident is fixed by the certificate of the certifying surgeon who at his discretion may antedate the happening of the accident—that is, the onset of the disease—from the time at which he examines the man to such a time as he considers the disease actually commenced. If either of the parties who are affected by the certificate of the certifying surgeon—the employer or the employee—is aggrieved at the action of the certifying surgeon, two courses are now open: (1) An appeal may be lodged against the certificate of the certifying surgeon by either of the parties for an arbitration in the county court; or (2) either party may apply for the case to be referred to a medical referee whose duty it is to decide whether or not the workman was suffering from the disease or is still suffering from the disease certified by the certifying surgeon. The decision of the medical referee is final. Neither of these procedures, however, in any way abrogates the civil law.

During the first few years of the working of the Act the medical referees appointed to the various county court circuits were employed as medical referees under the amending Act, but at a somewhat later period it was found that special knowledge was required by medical referees dealing with industrial diseases, especially lead poisoning, eye diseases, dermatitis, etc., and for this reason certain specialist medical referees were appointed by the secretary of state under Section 10 of the Act. These specialist medical referees are appointed for certain districts which include a number of county court circuits.

The ordinary procedure with regard to cases of compensable disease is slightly different in the case of employer and employee. In the case of an application by the employer, he undertakes to pay the employee any reasonable traveling expenses incurred in attending the examination by the medical referee. The registrar of the county court then forwards to the specialist medical referee Form 11, Workmen's Compensation Act (medical) which states that an application has been made for examination by the medical referee and certifies whether or not the workman is in a fit condition to travel for the purpose of being examined. With the notes are forwarded a copy of the application and a copy of the certificate of the certifying surgeon, to-

gether with any medical reports which may have been submitted by either party. On receipt of the notes from the registrar, the medical referee forwards a statutory notice of attendance to both parties stating that he has been appointed to examine the case, and fixing a time and place for the examination.

Should the workman be the applicant, the same Form 11 is sent by the registrar to the referee and the name of the employer to whom the statutory notice is to be sent by the medical referee is appended, but no traveling expenses are allowed to the workman. The certificate of the certifying surgeon either certifies that the workman is suffering from the disease or is a refusal so to certify. In the case of certification of the disease, the certifying surgeon is required to state the leading symptoms of the disease at the time of his examination. The medical referee, in notifying both parties, forwards a statutory notice which requires the two parties themselves or their representatives to attend at the place of examination. There is, however, no instruction or requirement in the Act for any other party to be present during the examination by the medical referee—in fact, it is inadvisable for the purposes of the actual examination of the case that any third party other than a relative should be present—but the medical referee is obliged to hear any evidence of either medical or general nature which may throw light on the case.

The decision of the medical referee is not given to the parties at the time but is given in writing on the special forms prescribed by the secretary of state, the wording of which is laid down, and the medical referee is only required either to allow or to dismiss the appeal against the certificate of the certifying surgeon. The specialist medical referee may, at his discretion, add to the finding for or against the certificate his opinion as to whether or not the workman has recovered from the disease. A copy of the certificate is forwarded by the specialist medical referee to the registrar of the county court from which the reference was received and to both the parties concerned in the case.

In order to facilitate the diagnosis and the proper evaluation of all the points germane to the case, the specialist medical referee is allowed pathologic assistance for the examination of blood or for any other special examination which he considers essential, but he must notify the secretary of state of the necessity of his so doing, a certain scale of fees being previously arranged with regard to the various examinations which may be required.

The foregoing gives a brief outline of the general procedure which is adopted under the Workmen's Compensation Act, which gives every facility for the careful sifting of the evidence and the examination of any special material that may be deemed necessary in making an accurate diagnosis. This is especially essential in some of the more difficult cases where such possibilities as the existence of syphilis may be suspected and where the greatest possible assistance is obtained by a Wassermann reaction. Every effort has therefore been made to safeguard the interests of the worker in carefully sifting the

medical evidence, and the method of referring the cases to a specialist medical referee was suggested as a means by which a good deal of unnecessary litigation might be avoided and a proper and careful medical diagnosis in difficult cases be insured.

TABLE 1.—COMPENSATION STATISTICS FOR FIVE INDUSTRIES, 1920 AND 1924

INDUSTRY		NUMBER EMPLOYED	NUMBER OF CASES COMPENSATED	NONFATAL CASES PER 1,000 EMPLOYED	TOTAL COMPENSATION PAID	COST PER PERSON EMPLOYED
					£	*s. d.*
Factories	1920	5,996,246	196,516	32.6	2,770,890	9.3
	1924	5,242,521	201,857	38.5	2,254,465	8.7
Shipping	1920	211,996	4,799	21.1	174,607	16.6
	1924	207,174	6,812	31.5	229,095	22.1
Mines	1920	1,249,884	145,377	115.3	2,329,514	37.3
	1924	1,202,597	230,984	191.0	3,376,214	56.2
Construction	1920	98,601	4,163	41.6	65,990	13.5
	1924	106,312	8,387	78.2	149,050	28.0
Railways	1920	553,059	18,367	32.5	322,453	11.8
	1924	520,663	21,789	41.3	298,904	11.6

Statistics of Compensation

In endeavoring to make a comprehensive study of industrial disease in its relation to compensation one has to rely on the statistics of compensation published by the Home Office in an annual return which is generally rather more than a year behind. I have been unable to obtain the 1925 return as it is not likely to be published before November of this year.

In taking the last return for 1924, certain very important and far-reaching facts have been gleaned. In 1911, when 7,305,997 persons came within the provisions of the Act, the actual amount of compensation paid for fatal and nonfatal cases reached £3,056,404, while in 1924, with an increase of only 20,000 in the persons coming within the scope of the Act, the actual payments were double those in 1911, namely, £6,675,038.

From the figures in Table 1 we find that while the factories had a larger incidence in 1924 than in 1920 of cases on which compensation was paid, the actual amount of money paid was smaller. Most of the other industries, such as shipping, docks, quarries, and railways, where the number of persons employed was not very much higher or was slightly lower in 1924 than in 1920, show an increase in cases and in compensation. These figures apply to both accident and disease compensation. I am not concerned with industrial

accidents, and in my own province as medical referee I deal only with the industrial diseases mentioned in the third schedule of the Workmen's Compensation Act. It is interesting to note, however, that while thirty diseases are scheduled, the bulk of the compensation cases fall under three headings: (1) diseases of miners, (2) lead poisoning, and (3) dermatitis. Thus, in the last return for 1924 (see Table 2), 92.5 per cent. of the total number of cases of industrial disease were derived from the mining industry, 2.7 per cent. were cases of lead poisoning, 4.2 per cent. were cases of dermatitis caused by dust or liquids and include cancerous ulceration of the skin, and 0.6 per cent., or 108 cases (twenty-five of which were cases of anthrax), were distributed among the remaining industries.

It would appear from Table 2 that the returns are curiously steady when taken over a period of years. You will see that the incidence of disease among miners has been largely due to miners' nystagmus, a condition and affection of the eyes. A considerable amount of attention has been given to elucidate the causes from which this disease arises, and it is confidently hoped that in the very near future a great amelioration will take place in the incidence of the disease. The numbers of new cases have already begun to drop considerably, but the industry is still fettered with numerous cases which occurred before the application of methods of prevention had come into force, and as many of these cases are chronic they naturally increase the statistics and pass on to weigh the figures from year to year. From the figures given in Table 2, the fall in new cases is obvious although preventive measures have been in existence for only a portion of the period.

Included in the miners' diseases are the affections known as beat hand, beat knee, beat elbow, and beat wrist. This is a condition of inflammation of the tendons or the tendon pads—"bursae," as they are termed medically—of the hands, knees, elbows, and wrists. The parts become swollen as a result of constant friction and afterwards become the site of infection. The Health Advisory Committee of the Ministry of Mines, which, I am proud to say, I was

TABLE 2.—COMPENSATED CASES OF DISEASE, 1919 TO 1924

DISEASE	1919		1920		1921		1922		1923		1924	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Nystagmus, new	2,718		2,865		1,913		4,092		3,883		3,271	
Nystagmus, old.	3,731	91.1	4,163	90.3	4,804	94.0	5,063	94.9	7,273	93.9	7,635	92.5
Beat hand, etc..	2,726		2,380		2,021		3,492		4,679		4,680	
Dermatitis.....	270	2.7	408	3.9	279	3.0	319	2.4	534	3.2	709	4.2
Lead poisoning.	231	2.3	265	2.5	230	2.5	273	2.1	381	2.3	449	2.7
Other diseases..	398	3.9	344	3.3	43	0.5	83	0.6	115	0.6	108	0.6
Total.....	10,074	100.0	10,425	100.0	9,290	100.0	13,322	100.0	16,865	100.0	16,852	100.0

largely instrumental in forming, has already made, through the medium of the Medical Research Council, a

culty. Moreover, there are other features which render its diagnosis as a true occupational disease one of

TABLE 3.—COMPENSATED ACCIDENTS IN MINES AND FACTORIES, 1919 TO 1924

YEAR	MINES					FACTORIES				
	Number Employed	Fatal Accidents	Disabling Accidents	Ratio		Number Employed	Fatal Accidents	Disabling Accidents	Ratio	
	A	B	C	B:A	C:A	A	B	C	B:A	C:A
1919	1,184,038	1,248	134,991	1:900	1:8	6,127,706	1,165	183,358	1:5,200	1:32
1920	1,249,884	1,231	134,738	1:1,000	1:9	5,996,246	1,276	194,232	1:4,700	1:30
1921	1,109,023	833	103,784	1:1,300	1:10	5,218,311	844	135,584	1:6,200	1:38
1922	1,122,511	1,067	201,370	1:1,000	1:5	5,119,388	708	138,478	1:7,200	1:37
1923	1,214,660	1,282	245,479	1:950	1:5	5,103,240	647	169,192	1:7,900	1:30
1924	1,202,597	1,265	214,171	1:950	1:5	5,242,521	793	199,768	1:6,600	1:26

research into the incidence and cause of this crippling condition, and it has been found, as I suspected when I first examined the health statistics of the mining industry, that the disease was due to neglect of small and early abrasions and injuries. The ambulance and first aid regulations introduced into factories some time ago have been extended to cover the mines, and I am hopeful that the incidence of this particular disease will show diminution in the near future.

Turning now to the other diseases which make up the bulk of the compensation cases of industrial disease, we find dermatitis showing a rise from 270 cases in 1919 to 709, or nearly three times as many, in 1924. This disease is protean in its manifestations, and is incident among the population at large, irrespective of any occupational cause, so that the estimation of its relation to the occupation of a worker is a matter of extreme diffi-

the very greatest difficulty; to these I shall have occasion to refer later.

The other form of industrial disease is lead poisoning, the figures of which have gone up from 231 in 1919 to 449 in 1924; the fatality of the disease, however, has diminished. The fatal cases in 1920 were eighteen in a total number of 265, while in 1924 the total was eighteen for 449 cases—a diminution in the four years of at least half the death rate. As a large number of these fatal cases are cases of old-standing illness and long-continued exposure before even the simple facts of general hygiene had been brought home to the workers, the death rate is likely to undergo a further diminution. The diminution cannot be ascribed to a decrease in the use of lead paint, as most of the cases of lead poisoning existing among painters, which after all make up only a proportion of the cases, are due to inhaling dust during

the dry rubbing down of painted surfaces, many of which were painted long before any attempts to introduce substitutes for lead were made.

TABLE 4.—DURATION OF COMPENSATED DISEASES AND ACCIDENTS, 1919 TO 1924

YEAR	UNDER 4 WEEKS		4 TO 13 WEEKS		13 TO 26 WEEKS		OVER 26 WEEKS	
	Accident	Disease	Accident	Disease	Accident	Disease	Accident	Disease
	%	%	%	%	%	%	%	%
1919	59.56	36.56	34.76	33.22	3.73	8.04	1.95	22.18
1920	58.22	31.70	35.62	30.25	3.99	10.52	2.17	27.53
1921	55.16	31.26	37.05	29.96	5.28	10.28	2.51	28.50
1922	55.21	33.14	38.44	39.29	4.47	7.34	1.88	20.23
1923	56.97	32.04	36.94	32.47	4.18	7.39	1.91	28.10
1924	62.71	39.45	31.89	34.04	3.62	6.74	1.78	19.77

The figures which I have already quoted are of interest to the insurance world, as they give the actual numbers of persons who have received compensation. Some of them are undoubtedly very high and unsatisfactory. I shall not enter into a discussion of the accident compensation returns beyond calling your attention to Table 3 in which I have contrasted two groups of workers—miners and factory workers. I would ask you to compare and contrast the figures for accidents and for industrial diseases (Table 2) and to note the excessive incidence in the mining industry.

One other series of figures may be adduced which has a further bearing on insurance questions, namely, the duration of compensable accidents and diseases, and I have presented in Table 4 a copy of the table given in the 1924 return of the Workmen's Compensation Act. The significance of these figures you can see at a glance, namely, that industrial accidents taken over a period of years, from 1919 to 1924, show a diminution in the number of weeks lost, whereas industrial diseases show an almost steady curve. It points, I think, to the fact that a very much larger number of trivial accidents come within the scope of compensation, but that by so doing, not only is the illness of shorter duration but considerable time, suffering, and expense are thereby saved.

We may next turn our attention with advantage to a consideration of the actual figures of compensated cases. They certainly represent a very serious handicap in many industries, and whatever may be attributed to the medical profession and the philanthropist or the political economist with regard to their desire and efforts to decrease the incidence of disease, it can hardly be asserted that the interest of the insurance world is entirely altruistic. No disparagement is made by such a consideration, and I think it will be admitted that one of the most powerful levers in attempting to shift the huge responsi-

bility in cost to any industry must be a monetary one.

Then let us look at the matter from a purely practical point of view. The speed of a fleet is the rate of the slowest ship; the cost of insurance for an industrial disease must be determined by the greatest incidence of the disease in any given factory—or individual factories or industries are loaded with an excess of insurance. Such an increase in the insurance rates in any disease must in itself be one of the strongest incentives for the employers to adopt inquiries and look for means for the prevention and diminution of disease, and I am of the opinion that far more can be done through the medium of the financial side of industrial disease and industrial accident through the purely compensatory monetary loss than by any other means, cynical though this may sound.

Personal Records

One further point requires consideration. I have referred to the machinery set up under the Act of 1906 for the certification of cases of industrial disease, and I have endeavored to explain the working of the Act from the purely medical point of view. You will remember the famous case known as *Bedford* v. *Cowlan & Sons, Ltd.* which I have already quoted. The certifying surgeon's certificate was not appealed against. Considerable care has been taken by the Home Office to endeavor that the certifying surgeons under the Factory Act appointed in various districts should be persons who are well qualified to diagnose various industrial diseases, and to my mind it is a matter of great importance that these men are chosen from among the general practitioners of the district, provided it is always recognized that from time to time the certifying surgeon may feel compelled in a case of doubt to make a certificate in favor rather than against the existence of a disease, but the machinery for the adjustment of such cases is adequate and, on the whole, satisfactory.

I have taken a few figures from my own examinations during a portion of the time that I have been acting as medical referee (Table 5). I find that of 156 cases referred to me for decision the certifying surgeon's certificate was upheld in 107 and disallowed in 49. Of these 156 cases 88 were lead poisoning, 53 industrial dermatitis, and 15 others. In view of the fact that this group of cases represents only a small percentage of the total, it will be seen that a not inconsiderable number of the certifying surgeons' certificates are reversed.

The regulations of the Home Office allow the expert specialist referee to obtain such further pathologic examinations as he deems essential in the various cases. Much has been made of the presence or absence of basophilia in lead poisoning, and I therefore give in Table 6 the results of blood examinations in fifty-four workers—by no means all the cases referred for examination. The number of cases positive for basophilia were slightly in excess of those which were negative, the accumulator workers showing the highest incidence. In seven of the cases in which a defi-

nite basophilia was noted, no symptoms of plumbism could be found, whereas in twelve cases negative for basophilia definite symptoms were present. While I consider the test for basophilia of considerable value, it is by no means in itself a certain and absolute criterion.

TABLE 5.—DECISIONS IN 156 CASES OF INDUSTRIAL DISEASE REFERRED TO MEDICAL REFEREE

DECISION	LEAD POISONING			DERMATITIS AND OTHER DISEASES	TOTALS
	Painters	Lead Workers	Accumulator Workers		
Certificate[1] upheld:					
Lead poisoning	20 } 25	12 } 17	15 } 18	47	107
Not lead poisoning	5 }	5 }	3 }		
Certificate[1] reversed:					
Lead poisoning	11 } 15	6 } 7	4 } 6	21	49
Not lead poisoning	4 }	1 }	2 }		
Total	40	24	24	68	156

[1] Of certifying surgeon.

TABLE 6.—RESULTS OF BLOOD EXAMINATION FOR BASOPHILIA IN FIFTY-FOUR WORKERS

OCCUPATION	BASOPHILIA	
	+	−
Painters	7	10
Lead workers	11	9
Accumulator workers	13	4
Total	31	23
Symptoms of plumbism	*24*	*12*
No symptoms of plumbism	*7*	*11*

With regard to dermatitis much confusion exists. About two and a half years ago an alteration was made in the form upon which the medical referee certifies cases of dermatitis, it having been upheld in the courts that while dermatitis was a disease which might be contracted in a given industry it did not necessarily preclude the sufferer from earning full wages at some other form of work of a similar nature in which he was not exposed to the deleterious action of dust or liquids. The incidence of dermatitis and its possibilities as an industrial disease are, however, enormous. It is not infrequently caused by washing up plates and dishes with the use of strong soda water, and therefore it is a risk to every domestic servant, every worker in a laundry, every baker, and every worker in a chemical factory of any description; in fact there is no agreement among medical men at the present time as to what may or what may not cause dermatitis in a susceptible person, and I must confess that I am somewhat alarmed at the possibility of the development of dermatitis as an industrial compensable disease.

In a subject so confused as that

under discussion it is impossible to do justice to the many aspects of the case. I have endeavored, therefore, to survey the ground in many directions and without a minute study of any special industry or disease in order to give a general outline of the medical aspects of the Workmen's Compensation Act from the point of view of the specialist medical referee.

WEAVERS' COUGH*

E. L. Middleton, M.D.

H. M. Medical Inspector of Factories

Introduction

THIRTEEN years ago Prof. E. L. Collis (then H. M. Medical Inspector of Factories) reported on the outbreak of an unusual illness among weavers of cotton cloth.[1] The illness occurred during 1910 and 1911 in a Lancashire cotton mill; in the spring of 1911 similar symptoms appeared in a mill at Colne, and recurred in June, 1912; and in the same month the weavers in two weaving sheds in Burnley were affected, those in one so severely that the shed had eventually to be closed for a short period.

In the process of weaving, long threads, known as the warp, are drawn slowly forward on a loom from a warp beam on to which they have been wound before being placed on the back of the loom. Cross threads, the weft, which have previously been wound on to spools, now known as cops, are placed in shuttles which, during weaving, are thrown mechanically across and through the warp threads held open to permit the shuttle to pass.

The following description taken from the earlier report explains the environmental conditions associated with the illness.

In each case the symptoms occurred in a "dry" shed in which cloth is woven for subsequent bleaching, printing and dyeing. Such cloth differs in the process of manufacture from other cotton cloth, in two respects: a smaller quantity of size is applied to the warp threads, and the antiseptics (usually added to prevent occurrence of mildew on the cloth at a later stage) are omitted, since dyers specify that no chlorides (zinc chloride is the antiseptic generally used) shall be present in the goods they buy. Size is composed of various ingredients, of which the most important are flour (derived from wheat, sago or potatoes), tallow, china clay and water. Cotton threads passed through such a preparation, in the absence of any antiseptic, form, if not thoroughly dried, an excellent soil for the growth of moulds. Mildew spores, which are present in any atmosphere, must settle on the threads as they are wound from the sizing machines on to the warp beam. Moreover, to cool and further dry the threads as they pass off the warm cylinders, paddle fans, revolving close to the bottom of the machines, drive air against the threads, to which, if they are damp, any spores in this air will readily adhere. Conditions favourable to the development of mildew appear to have been present wherever the illness has occurred. Thus the outbreak at Colne in 1911 was preceded by a complaint from the weavers that threads were frequently breaking and impeding work, which was attributed to "dry taping" of the warp threads (the technical term for the process of applying size to warp threads is

* Received for publication Feb. 17, 1926.

[1] Collis, E. L.: Report on Unusual Illness among Weavers of Cotton Cloth. London, H. M. Stationery Office, 1913. See also Proc. Roy. Soc. Med., 1914–1915, *8*, Part 2, Epidem. and State Med., p. 108.

known as "tape sizing" or "taping"). To remedy this trouble "wet taping" was resorted to, i.e., threads were passed quickly over the drying cylinders of the sizing machine and, while still containing moisture, wound on to the warp beam. When these threads were placed on the looms they showed signs of mildew, and the illness broke out. Dry threads were substituted for the mildewed ones and the symptoms disappeared. During May, 1912, which was a month of dry weather, the firm thought it advisable to revert to wet taping; in June, however, contrary to expectation, damp weather prevailed, mildew again appeared and with it the symptoms; when the mildew was got rid of, the symptoms, never so pronounced as in the previous year, disappeared.

The symptoms which occurred then are also worth restating.

The first sensation experienced is one of constriction of the chest beneath the sternum; this feeling extends up towards the larynx, and the act of breathing becomes an effort. Next, breathing becomes rapid and rather shallow with occasional deep sighs, and a persistent irritating cough develops. This cough is associated with expectoration of thick yellow or yellowish-green sputum and a sweetish taste in the mouth. Later the difficulty in breathing progresses until it resembles asthma and may prevent the sufferer from sleeping, or arouse him from a disturbed rest fighting for breath, and drive him to throw open the bedroom window for air. Food may be rejected in a spasm of coughing, epistaxis may occur, and the fauces are found red and inflamed. The individual suffers with general malaise, aching limbs and back, severe headache which is usually frontal, and shivering, ending in perspiration; in a few cases where the temperature has been taken it has been found to be from 100°F. to 102°F. in the evening, but no temperature above normal has been recorded earlier in the day. As the symptoms persist the individual cannot hurry when walking, finds an ordinary slope difficult to climb, and tires rapidly; the appetite becomes affected and weight is lost. Pronounced cases have been deprived of sleep for a week and have been confined to bed, but those less affected have managed to remain at work.

In 1924 a further outbreak occurred at Burnley and was investigated by Dr. J. C. Bridge, H. M. Medical Inspector of Factories,[2] the circumstances being identical with those of previous inquiries; mildewed warps were present in the shed from the commencement. Though the number of persons actually absent on this occasion was not great, those who were suffered from persistent cough and loss of weight as the chief symptoms. No further light was thrown on the actual cause of the cough, but samples of mildew were collected from which the following information was supplied by Dr. Crossley of the Shirley Institute of the British Cotton Industry Research Association:

Sample "A" labelled as "Taken from the warp bar at the back of the loom" was pale grey in colour and consisted of:—

(1) fragments of cotton hairs;

(2) fragments of fungus mycelium;

(3) fungus spores of two sizes and also conidiophores.

Conidiophores of Aspergillus flavus and Penicillium species were recognisable, so that it was concluded that the larger spores were those of "A" flavus and the smaller ones Penicillium. The cultures, however, developed colonies of Penicillium and one other fungus which it has not yet been possible to identify, so that the presence of Aspergillus cannot be regarded as established yet. Penicillium, however, predominated to an extent which made the second fungus almost negligible.

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[2] See Ann. Rep. Chief Inspect. Factories and Workshops for 1924. London, H. M. Stationery Office, 1925, p. 80. Cmd. 2437.

Present Investigation

The subject of this paper is the investigation of a further outbreak which occurred in 1925 and reference to Professor Collis' report leaves little doubt that the illness described then and that under review now are one and the same.

The weaving shed in which the most recent outbreak occurred is one of the two tenement factories which are separated by an incomplete partition. The shed contains 955 narrow looms weaving plain cloths, and is ventilated by sixteen exhaust fans placed in the roof. Artificial humidification is not practised.

Sizing Process

The warp is sized by two machines, that from each machine bearing a distinctive mark. It is possible, by adjusting the speed of the drying cylinders over which the sized warp is passed, to preserve a varying quantity of moisture in the warp as it is wound on to the beam. The "taper" employed on one of these machines admitted allowing a greater amount of moisture than usual to remain in the warp, on account of the dry weather prevailing at the time; 95 per cent. of the warps, subsequently found to be affected with mildew, were said to have been sized at this machine. The arrangement of the sizing machine is such that, as the warp passes from the hot drying cylinders to the beam on which it is finally wound for use in the loom, it is cooled and dried by means of large paddles which revolve close to it. One effect of leaving a considerable degree of moisture in the sized warp is to provide a suitable medium for the growth of fungi which may have escaped destruction in the size beck, or may be thrown on to the warp by the paddles, as it is wound on to the beam. Since the warp may remain in storage for a few weeks before it reaches the loom, and four weeks more will pass while it is being worked off, mold fungi will have time to attain considerable growth.

Mycologic Examinations

In the first instance the outbreak of illness was reported to the Inspector of Factories by the occupiers and by the officials of the Weavers' Union, and an investigation revealed the presence at the mill of a consignment of weft which was so seriously affected with mildew that much of it was returned to the spinners. Samples from affected cops (of weft) were submitted for mycologic examination to the Shirley Institute. The report stated that two cops were examined and that one showed the presence of several species of Penicillium, a fungus like Record 11, but blue instead of white, and occasional colonies of other molds.

Samples were also submitted of dust taken from the bearers of three looms (dust from the warp). The report on these samples was as follows:

> The plates were alike showing colonies in the proportion of—
>
> (1) Mucor, 1,
>
> (2) Penicillium, 30 (one species only),
>
> (3) Unidentified, 50,
>
> (4) Occasionally a colony of A. niger.
>
> These cultures were therefore very characteristic, No. 3 being the hitherto unidentified mildew encountered in 1924. It was the characteristic fungus of the dust samples we examined on 16.11.24 [from a mill affected with weavers' cough].

There is evidently no connection, therefore, between the mildew on the weft and the dust on the warp bar.

An unusual amount of mildew was found on many of the warps during the course of this outbreak, and special attention was directed toward remedying this. Some of the affected warps were destroyed; others were treated with size containing salicylic acid; and 500 warps had skeins of yarn, rung out of a solution of salicylic acid (1 in 160), hung in contact with them on the looms and freshly rung out twice a day.

Position of Affected Workers in the Shed

A chart of the shed with the positions of the looms was prepared and the positions of the affected workers were plotted out on it. No causal relationship, however, was seen to exist between the respective positions; the distribution was fairly uniform, though the zone near, but not close to, the partition between the two sheds was least affected. The same applies to the position of the ventilators, but as these are distributed at almost equal intervals, no notable relationship could exist.

Incidence of Cases Leaving Off Work

The first patient left off work on May 25, 1925, and four patients left during June, three on consecutive Mondays—the 15th, 22nd, and 29th—and one on the 30th. The annual holidays occurred from July 3 to 13; during this time the shed was disinfected by the Local Sanitary Authority by spraying with formaldehyde solution.

Work was resumed on July 13. Three workers were absent on this day, four more were absent on the 14th, and small numbers of abstentions occurred on nearly every working day up to the 29th; a total of thirty-two abstentions occurring in July. The mill was closed from August 1 until August 10, and the shed was again disinfected. The treatment of the warps with salicylic acid was also carried out at this time.

Work was resumed on August 10. There were thirteen abstentions on the 11th, and small numbers on nearly every working day until the 24th, when the last case occurred. The mill was closed for autumn holidays from September 5 to 10. There have been no new cases of illness since.

The total number of persons employed in the shed, including 8 tacklers (overlookers) and 26 tenters (apprentices), was 85 males and 160 females. Of the males 17 were affected—15 weavers, 1 tackler, and 1 tenter; of the females, 42 weavers, making a total of 59 persons affected and off work.

Air Tests

Air samples were taken with Owens' dust counter and with the settlement dust counter in the weaving shed, sizing room, and other places. In all the records there were large numbers of conidia of mold fungi, and fragments of mycelium. Over the healds of a working loom a count of 57 conidia per cubic centimeter of air was found; other samples gave counts of 10 and 24 conidia per cubic centimeter. Conidia and spores of mold fungi were

found in records taken close to the paddles of the sizing machines.

Symptoms and Course of the Illness

CASE 1.—This was the first case in the present outbreak. The patient was a man who had been affected during the outbreak which occurred in 1911 at another mill in Burnley. At that time he was off work for three weeks. On the present occasion he had a cough for four or five weeks before he gave up work on May 23. Dyspnea and cough were the worst symptoms, being most severe in the morning and at night; he had to lie on his back, and sometimes had to get out of bed, because of the severity of the cough. About the middle of June he returned to work feeling well, but by noon of the same day the symptoms had returned as bad as before. A specimen of sputum was examined on July 22; stained smears showed numerous conidia and fragments of mycelium. When the patient was examined on August 10 the symptoms were confined to cough and expectoration in the morning. On examination of the chest the percussion resonance was good, the breath sounds were vesicular in all areas, with a fine whiffing quality in both upper anterior areas; an occasional rhonchus was heard in the right upper posterior region.

This history is fairly typical of a majority of the cases, and the physical signs are similar to those found in patients after the acute condition had subsided. The gradual onset in the first instance is noteworthy when contrasted with the rapid recrudescence, in a few hours, of the symptoms on returning to work. This feature was present in a number of cases, suggesting a sensitization to the irritant on reexposure after subsidence of the first attack, or, alternatively, an acquired tolerance which was rapidly lost when the causal factor was removed for a time. The violent character of the second attack, no doubt, deterred some of the patients from returning to work. There is evidence that cough might exist for a time without a patient's leaving off work and that a severe exacerbation occurred after a short period of absence from work.

Unlike the cases described by Dr. Collis, a number of these cases gave a history of gastro-intestinal disturbance accompanying the respiratory symptoms. The following case is cited as an example:

CASE 2.—L. W., a female weaver, had some dyspnea and expectoration for a few weeks, but was never off work until the mill was closed at the end of July. When she resumed work on August 10, dyspnea came on and increased during the day; at night there were vomiting and loss of appetite.

The nonrespiratory symptoms occasionally occurred alone, as in the following case:

CASE 3.—J. T., a male weaver, not regularly employed at this mill, started, on July 14, at four looms previously worked by a female weaver who was off with the cough, and worked off the remainder of four warps left on the looms. Just before the closing of the mill on August 1 he felt burning in the throat and mouth but he recovered completely during the stoppage. On resuming work when the mill opened on August 10, he felt quite well, but on the 11th he felt the burning sensation in the throat and mouth, sickness, giddiness, and headache; he had no cough and only slight dyspnea; giddiness and a coated tongue were the chief symptoms. The gastric and respiratory symptoms have been met with in the same patient in different attacks.

CASE 4.—B. H., a female weaver, aged 16, was sick and vomited on resuming work after the holidays on July 13. After a

week's absence, while the mill was closed, she returned to work on August 10; cough, severe dyspnea, and a feeling of suffocation came on in the afternoon of the same day, and she had to go home at 4 o'clock. Examination of the chest on the day following revealed no physical signs.

CASE 5.—E. P., a female weaver, "felt bad" before the holiday stoppage in July, but kept at work. After extra holidays she resumed work, quite well, on August 10 and worked all day, but felt the throat "smarting." At night, dyspnea, cough and crowing breathing, and a feeling of the chest being made up came on and kept her awake all night; there was scanty sputum, expectoration with difficulty, and a feeling of sickness with the cough.

CASE 6.—A female weaver, E. C., aged 51, became affected the first day after the holidays, July 13, with sickness, vomiting and diarrhea, cough and dyspnea; she left off work the next day. She returned to work on July 20 and worked two days, when the same symptoms returned as bad as before. When seen on September 6, she was still weak, but otherwise was free from symptoms. Prior to the attack she had never been off work. During her absence from work her sister took her place at the looms; she suffered from cough and sickness, but remained at work.

CASE 7.—This patient, a female weaver, left off work on June 24. For a week or two before this she had gradually increasing dyspnea and cough. After an absence of three weeks, she returned on July 16 and by 11 o'clock she had cough and was expectorating green sputum; she worked till 5:15 but had to send for the doctor on account of cough and vomiting. The symptoms cleared up after a few days. Increased sensitivity was noted by this patient.

CASE 8.—E. S., a boy aged 14, was employed as a tenter to a six-loom weaver who remained unaffected. He commenced work in April. About the middle of June he began to be ill with sore throat, cough, pain in the stomach, and vomiting; there was no diarrhea. He remained at work till the holidays, July 1. He returned to work on July 13 and the symptoms returned, but he worked all the week; he was off from July 20 to 25. He returned again to work on Monday (27th) and at 11 o'clock the cough came on again, and he had pains in the stomach and back; he had no appetite for dinner. He worked until 4 P.M. and then went home to bed. He returned to work on August 10 and worked only one day; he was off until the 17th when he worked until the 19th but gave up and had not worked again up to September 6. He was a remarkably healthy looking boy and apart from a slight cold had no symptoms.

The converse of Case 8 was seen in a girl tenter, aged 14, a mouth breather, of rather poor physique, who remained unaffected, while the weaver for whom she worked was off work from July 14 till August 10. The looms on which she worked were close to those on which the boy tenter, E. S., was employed.

The cases which have been cited are individual instances, rather than types, of the illness; for it can hardly be said that the symptoms lend themselves to grouping on hard and fast lines. The central picture, however, occurs with sufficient regularity to form a basis for diagnosis, namely, the prodromal irritation in the upper air passages; the feeling of obstruction in the breathing, described as the chest being "made up;" the paroxysmal cough; and the scanty, tenacious sputum. These symptoms commonly followed resumption of work after an interval away from it, and there was usually a history of some respiratory trouble before the period of absence from work, in itself insufficient to produce incapacity. The several symptoms varied in importance in the different cases, as might be expected, and the degree of incapacity showed

still greater differences. There is no doubt that some, possibly many, of those who never left off work, suffered considerably from cough and dyspnea.

Most of the acute cases appeared to improve rapidly after removal from the shed. After the first twenty-four or forty-eight hours, the symptoms lost much of their distressing character and soon subsided to a period of coughing in the morning and at night. In some cases there was a tendency for this stage to be protracted, possibly owing to more extensive, initial inflammatory change, or to a preexisting bronchitis.

Prognosis

In regard to the prognosis of these cases, there appear to be two possibilities: (1) that the condition clears up after a varying period of removal from the shed; (2) that the symptoms remain, more or less, and a chronic condition is established. To illustrate the second possibility a case may be noticed of a man, G. R. R., who was not employed at the mill now under review, but was a weaver at another mill in Burnley where an outbreak occurred in 1924. G. R. R. had been a weaver at the mill for six years; on June 4, 1924, he suffered from cough, dyspnea, and a "made up" feeling in the throat, and he had to leave off work on the third day of illness. He suffered from cough persistently for four months and then intermittently throughout the winter. On resuming work on July 13, 1925, after the annual holidays, in the same mill, where no new cases had arisen since 1924, the symptoms returned on the first day of work, and he had to give up work and has been off since. He feels quite well when outside and has tried to get outside work; now, there is occasional slight cough, rarely any sputum, and no dyspnea when he is in the open air. Examination of the chest showed relatively diminished air entry and scattered rhonchi over the left side, back and front; the right side was clear except for an occasional rhonchus and a slight harshness of the breath sounds.

Besides the chronic condition, there is a third possibility—that a lung disease is produced, resembling pulmonary tuberculosis. One worker who developed symptoms during the present outbreak was sent to a sanatorium with a diagnosis of pulmonary tuberculosis. Inquiry at this institution only yielded the information that the diagnosis had not been confirmed. An account was obtained from the parents of a worker who was employed in 1911 at the mill in Burnley in which an outbreak of weavers' cough occurred; as a result of an attack at that time, she was off work for four years with a condition described as "tuberculosis of the throat," from which she recovered. She was employed at the mill where the present outbreak occurred and went off work with weavers' cough on July 20, 1925.

In some cases the symptoms included pyrexia, night sweats, and loss of flesh, and the resemblance to pulmonary tuberculosis was close enough to cause difficulty in diagnosis.

Etiology

Of the etiology of this disease it is not possible to speak at this stage.

The first thing to strike an observer is that it is not like any epidemic disorder which is met with in a mixed community; it is not, for example, like the common cold. While there are coughs among weavers, possibly more than in the average mixed population, it is impossible that this disease could have been occurring in other mills in important proportions, for the workers' societies would have been aware of it. There seems to have been an unusual factor at work in this weaving shed which was not present in any other at the time. The fact that the cotenants were not affected rules out anything which would be common to both and specifies a material sufficiently localized to avoid diffusion over the incomplete partition between the two sheds. Materials such as cotton yarn could not alone produce the conditions in one factory and not in others to which it had been supplied. The methods of working were the same as had been in use for years without previous experience of the trouble. Of extraneous sources of possible trouble, one which was the subject of scrutiny was canal water which is used in the size beck; this was not examined chemically or bacteriologically as it might have been, because it has been used for the purpose for years and it is laid on to the factory.

From the material aspect of the problem the most probable cause of the outbreak is the greater amount of moisture left in the warp, producing an abundant growth of mold fungi which developed during storage on the beams and produced, on weaving, a dust laden with conidia, spores, and fragments of mycelium, which was breathed by the weavers. The source of such mold fungi or mildews may be the cotton fiber itself, or any source of contamination where the fungus finds a suitable medium for prolific growth. From the medical aspect very little is known of the action of mold fungi which are likely to be found in these circumstances. The effects may be produced by a mere increase in the number of particles of common molds which are ubiquitous and, in ordinary proportions, produce no known effects, or they may be due to a specific organism, mold fungus or lower form of fungus, the occurrence of which is rare or the conditions for the growth and propagation of which do not often occur. For the solution of this important problem, a highly specialized technic and adequate facilities are necessary. During this investigation repeated efforts were made to obtain information likely to throw light on the causal conditions, but with little success. The resources of existing scientific institutions are not easily adapted to the restricted field of this inquiry, and while work might be done on either the medical or the industrial aspects by separate competent bodies, the essential unity of the problem in all its aspects, and, above all, the urgent need for immediate action when the outbreak occurs, demand, rather, that suitable arrangements be laid in train beforehand. Arrangements have now been made, which should enable an investigation on the two aspects referred to above to be put in hand immediately.

DUST IN COTTON CARD ROOMS*

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MANY years have elapsed since attention was first drawn to the baneful effects, on the health of the workers, of the dust in the air of certain parts of cotton spinning factories. The subject has been investigated both from the point of view of the origin and characters of the dust, and from the point of view of the effects which were produced on the workers. Of the processes of cotton manufacture, the preliminary stages were always the source of the greatest amounts of dust, and the dust produced in the card room has generally proved the most difficult to control during the great advances which have been made in the design, structure, and ventilation of the factories and in the improvements of machinery.

Carding Process

The cotton reaches the card room after it has passed through the blowing room, where much of the coarsest extraneous matter has been removed. The carding machine consists, essentially, of a series of cylinders the surfaces of which are closely set with fine needles; the effect of this machine is to separate the cotton hairs and to bring them parallel to each other, and to deliver them on the doffer, ready to be removed in the form of the sliver —the delicate rope of fluff which is the first promise of the yarn. There are two kinds of carding machines: (1) the revolving flat card and (2) the roller and clearer card. The first deals with the new cotton from the blowing room and is provided with very fine needles, fixed in a special way over the carding surface. The roller and clearer card is used for dealing with waste and other cotton, rejected or dropped by the revolving flat card; the needles on the rollers of this machine are stouter than those of the revolving flat card and are not set so close together. This type of carding machine works in pairs, the breaker card being followed by the finisher card.

The most important difference between the two kinds of carding machines, from the point of view of the dust produced, is that firmly adherent extraneous matter, husk, and immature hairs will be more frequently liberated by the revolving flat card, whereas broken and short staple cotton hairs with less extraneous matter will be produced by the roller and clearer cards; where the waste treated in the latter type of machine contains impure, rejected cotton, however, this difference will be reflected in the dust produced.

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Stripping Process

At frequent intervals the cards have to be cleared of the adherent cotton débris and dirt which tend to be retained between the needles on the cards and to reduce their efficiency; this is done by stripping the cards. There are various ways of stripping the cards; two or three of these methods may be employed on the same machine: The hand strickle, which is a kind of wire brush, is a simple appliance which produces much dust; various kinds of brushes made to revolve by power, with or without localized exhaust draft, all produce more or less dust; so-called vacuum strippers, which can be applied close to the surface of the card, are of the type most generally free from the production of dust, the dust being removed by strong suction along the duct system to the extractor. The vacuum type of stripper, however, is not completely effective in clearing the cards and recourse must be had, at intervals of a week or so, to the use of the revolving brush. Subsidiary processes of brushing and dusting the machines might, with benefit, have vacuum cleaning methods substituted for the prevailing practice of throwing the dust into the atmosphere. Stripping of the cards is done by teams of men whose whole time is occupied with stripping and grinding the cards.

Grinding Process

Grinding, the purpose of which is to sharpen the points of the needles on the card surfaces, is done by placing a roller, covered with emery cloth, against the surface to be ground; the roller is then allowed to revolve slowly and requires little or no close attention. The first few revolutions of the cylinders, after mounting the grinding roller, are sometimes accompanied by the evolution of clouds of fine, irritating dust.

Data from Dust Determinations

The present investigation was undertaken in order to provide some data with regard to the character and quantity of the dust given off in card rooms, with special reference to that occurring during the stripping and grinding of the cards. The means adopted were the taking of dust records with Owens' jet dust counter and Owens' settlement dust counter, and the making of observations on the processes as carried on in eleven factories in Lancashire during July, 1925.

There are three main variables: (1) the kind of cotton; (2) the general condition of the factory relative to air space, floor space, separation of processes, number of machines working, and general cleanliness; and (3) the provision of general and localized ventilation. So great are the effects of these factors and so wide are the limits within which they vary, that no basis of comparison can be said to exist between one set of conditions and another. The effect of this variation on the value of dust determinations is such as to set aside any conclusion to which this or that count may seem to point, and to indicate that only general evidence of the manner in which the atmospheric dust varies in amount can be adduced as the result of this investigation.

More definite, however, is the evi-

TABLE 1.—SHOWING DATA FROM SAMPLES TAKEN WITH OWENS' JET DUST COUNTER

NO. OF SAMPLE (1)	FACTORY (2)	COTTON (3)	SOURCE OF SAMPLE (4)	VENTILATION (5)	RECORD (6)	COUNT (*particles in 1 c.c.*) (7)
			General Air of Card Room			
1	H	Good mid American.	Air of card room, 5 min. after stripping, with exhaust applied close to machine.	Fans (3 × 36 in.) collecting from 110 cards.	Not dense; some fragments of husk and short cotton; mineral; considerable amount of fine particles, possibly smoke.	301; over 1μ.
2	B	Mixings of mid and low American and best E. Indian.	Air of big card room in center of room.	Fans in window spaces and short length of duct at one end of card room.	A few stiff hairs; many spores and mineral particles.	325; over 1μ.
3	I	Low American.	Air of shed portion of card room; visible dust less than usually found. Conditions vary considerably.	Stripping done by Cook's stripper and special vacuum attachment to brush.[1]	Not dense; a few hairs, conidia, spores, fragments of fungus, and droplets of oil.	349; over 1μ.
4	A	Low grade Egyptian (Sakelarides).	Air of south end of card room, near middle.	General exhaust, with ducts and hoods at intervals above carding machines.	Rather dense, owing to great number of smaller particles, mineral and vegetable; some fibers, husk, fungus, etc.	1,012; over 1μ.
			Carding Process			
			Revolving Flat Cards—over the Doffer Comb			
5	B	Mixings of mid and low American and best E. Indian.	Over doffer comb of carding machine in motion.	General: fans in window spaces and short length of duct at one end of card room.	Coarse fibers, mineral, mold spores, and fine particles.	542; over 1μ.

6	E	Best Egyptian (Sakelarides).	Over doffer comb of carding machine in motion in center of no. 1 card room.	.....	Not dense; very few coarse particles; many conidia, spores, and fragments of fungi; some mineral.	554; over 1μ.
7	E	Best Sea Island.	Over doffer comb at other end of same room as sample 6.	.....	Very like sample 6; slightly fewer large particles; fragments of fungus, conidia, spores; some mineral.	590; over 1μ.
			Revolving Flat Cards—between the Flats			
8	H	Good mid American.	Between flats of carding machine in motion.	Fans (3 × 36 in.) collecting from 110 cards.	Not dense; comparatively little coarse débris, some coarse mineral and fine particles.	301; over 1μ.[2]
9	I	Low American.	Same as for sample 8.	Same as for sample 3.	Fairly dense; masses of mineral matter frequent.	458; over 1μ.
10	B	Mixings of mid and low American and best E. Indian.	Same as for sample 8, in small card room.	Same as for sample 5.	Much coarse fiber; fungus and coarse mineral.	699; over 1μ.
11	E	Best Sea Island.	Between flats of same carding machine as in sample 7.	.....	Medium; coarse mineral noticeable and a fair amount of coarse fiber.	710; over 1μ.
12	E	Best Egyptian.	Same as for sample 6.	.....	Dense, with largest amount of coarse mineral of the series; considerable amount of coarse fiber and many spores.	1,048; over 1μ.

[1] Rigby & Wolfenden, Rochdale.

[2] Cf. sample 1; general air of card room at this machine gives same number of particles.

TABLE 1.—*Continued*

NO. OF SAMPLE	FACTORY	COTTON	SOURCE OF SAMPLE	VENTILATION	RECORD	COUNT (*particles in 1 c.c.*)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Carding Process—*Continued*						
Roller and Clearer Cards						
13	J	Low waste; Indian cotton and fly.	At taker-in of breaker card.	Exhaust.	Medium; considerable amount of fiber, fungus, and coarse mineral.	193; over 1μ.
14	J	Same as for sample 13.	At taker-in of finisher card, in sequence with sample 13.	Exhaust.	Not dense; smaller fragments of cotton; spores, conidia, and molds.	76; over 1μ.
15	J	Fly and drop.	At taker-in of breaker card.	No exhaust.	Not dense; coarse mineral; few larger fragments of cotton; conidia.	64; over 1μ.
16	J	Same as for sample 15.	At taker-in of finisher card in sequence with sample 15.	No exhaust.	Sparse record; very little coarse débris, a little fungus; some coarse mineral and oil.	26; over 1μ.
17	F	Waste.	Near doffer comb on breaker card.	Exhaust fitted to machine cover.	Very few fibers, very little coarse mineral, fungus, and fine fragments.	124; over 1μ.
18	F	Waste.	Same as for sample 17.	Without exhaust (cf. with sample 17).	More fiber fragments and coarse mineral than in sample 25; not dense, on the whole.	144; over 1μ.
19	K	Hard waste and comber waste.	Over doffer of breaker card.	Plenum without humidity. Temp. 80°F. No exhaust.	Very few large fragments, many fine particles.	.....

			Stripping Process			
			Revolving Flat Cards			
20	A	Low grade Egyptian (Sakelarides).	At breathing level, stripping revolving flat card with Cook's stripper in north end of card room.	General exhaust with ducts and hoods at intervals above carding machines.	.....	1,108; 11% over 2μ.
21	G	Good American.	Near stripping brush when stripping, cylinder of revolving flat card fitted with vacuum exhaust on brush.	.....	Extremely dense; particles matted together.	Uncountable, owing to dense overlapping of fragments.
22	G	Same as for sample 21.	Near stripping brush when stripping doffer of same machine as for sample 21.	.....	Not nearly so dense as in sample 21; many spores and conidia.	632; over 1μ.
			Roller and Clearer Cards—by Hand Strickle			
23	C	Hard waste with proportion of bobbin waste.	Close to cylinder during stripping.	Wall fans, no localized exhaust.	Very dense record; coarse mineral particles up to 10μ or more; much vegetable matter including short sharp hairs.	Uncountable, owing to overlapping.
24	C	Same as for sample 23.	Stripping doffer.	Same as for sample 23.	Not so dense as in sample 23. Very large fragments with very few small particles.	168; over 1μ.
25	F	Waste.	Over cylinder of finisher card during stripping by hand.	Exhaust fitted.	Very coarse fragments.	205; over 1μ.
26	J	Low waste; Indian fly and drop.	Over cylinder while stripping.	Without exhaust, 2 fans with connections to casings of each card.	Not a dense record; coarse fragments and mineral particles.	76; over 1μ.

TABLE 1.—*Concluded*

NO. OF SAMPLE (1)	FACTORY (2)	COTTON (3)	SOURCE OF SAMPLE (4)	VENTILATION (5)	RECORD (6)	COUNT (*particles in 1 c.c.*) (7)
			Roller and Clearer Cards—by Trimmer			
27	D	Low quality American seed cotton and waste.	Trimmer stripping dust.	General exhaust at height of 3 ft. over trimmer.	Cotton fragments, fungi, and mineral particles.	403; over 1μ.
			Grinding Process			
			Revolving Flat Cards			
28	A	Low grade Egyptian (Sakelarides).	Grinding revolving flat card in same room as for sample 4.	General exhaust, with ducts and hoods at intervals above carding machines.	.....	1,000; 15% over 2μ.
29	B	Mixings of mid and low American and best E. Indian.	Close to grinding wheel, grinding revolving flat card.	Fans in window spaces and short length of duct at one end of card room.	Fragments of hairs; mineral matter.	578; 18% over 2μ.
			Roller and Clearer Cards			
30	C	Hard waste with proportion of bobbin waste.	Grinding card.	Wall fans.	Sparse record; fine mineral dust; scattered vegetable particles.	289; 15% over 2μ.
31	F	Waste.	Over cylinder of finisher card during grinding.	Exhaust.	Fine particles, probably smoke with many mineral particles, clear and opaque; some débris, conidia and fungus; much emery over 2μ.	1,012; 13% over 2μ.

dence regarding the character of the dust. In all the samples the same general characters are to be found; while the particles vary greatly in number, and while in different samples this or that ingredient predominates, no single characteristic is peculiar to one kind of cotton or to one set of conditions. The greater bulk of the dust is composed of vegetable débris of many kinds: fragments of cotton hairs, and of husk, fungus mycelium, conidia, spores, etc. One variety of sharp-pointed hairs could be found in varying numbers, usually scanty, in every record; from the microscopic appearances of this hair, it seems unlikely that it would constitute an important factor in health impairment. Mineral matter is present in every record and varies within very wide limits; the general characters are rounded particles or masses from 2 microns to about 40 microns, commonly from 10 to 20 microns; some of these are smooth spherical or ovoid—that is, fine sand.

The data presented in Table 1 are derived from a series of thirty-one dust determinations made with Owens' jet dust counter. This instrument insures that a very high proportion of the finer particles present in the atmosphere are collected on the record, together with a considerable amount of the dust which can pass through the jet orifice which is 0.1 mm. wide and 1 cm. long; long fibers or large masses of husk, etc., would not be collected by this instrument, and for these the records of the settlement dust counter can be studied (see Table 2).

Smoke particles are notably reduced in those records which show a high count of coarse vegetable particles. In order to make the results comparable, therefore, particles under 1 micron and smoke aggregates have been excluded from the counts of records, except in the case of grinding records, for which it is important to include small particles down to 0.5 micron in size.

Jet Dust Counter

Carding.—More dust of a kind liable to be inhaled is sent into the atmosphere from between the flats of revolving flat cards than from the doffer, and the particles from the latter tend to be larger. The general effect of different kinds of cotton on atmospheric dust content can be seen from samples 8 to 12; these are arranged in order of increasing counts. It will be noted that the doffer samples, numbers 5 to 7, are of the same order of density. Comparing the samples from the roller and clearer cards with those from the revolving flat cards, it is evident that the counts of particles in the former series are much lower in every instance than in the latter series. There may be several factors producing this effect, and of these the following may be mentioned: The construction of the revolving flat card permits a closer approximation of the sampling instrument to the point of origin of the dust, and in this way a larger proportion of the escaping dust will be caught in the instrument; cotton waste may be supposed to contain less of the fine dust than does the new cotton, and it is the fine dust which increases these counts; the action of the revolving flat card is, probably, of a more intimate nature and thereby tends to liberate more fine particles.

Stripping.—With Cook's stripper (a vacuum type of stripper which acts

TABLE 2.—SHOWING DATA FROM SAMPLES TAKEN WITH OWENS' SETTLEMENT DUST COUNTER

NO. OF SAMPLE (1)	VOLUME (2)	TIME (*minutes*) (3)	FACTORY (4)	COTTON (5)	SOURCE OF SAMPLE (6)	RECORD (7)
General Air of Card Room						
1	..	5	A	Low Egyptian.	In south end of card room.	Cotton hairs, husk, and mineral—coarse and fine.
2	..	22	E	Best Egyptian.	In middle of card room.	Remarkably little dirt; a few fibers and mineral particles.
3	..	?	A	Mid Egyptian.	On calender cover in front of revolving flat card in north end of card room.	Cotton hairs; coarse and fine mineral; a few husk fragments.
4	..	10	B	Mixings of mid and low American and best E. Indian.	In middle of large card room.	Much coarse and fine mineral; short cotton hairs and fragments of various kinds—evidently a dirty cotton.
5	..	20	B	Same as for sample 4.	In extension of card room.	Much dirt of all kinds.
6	..	15	I	Low American.	In middle of shed portion of card room.	Not dense; a few cotton hairs; some finer fragments and mineral particles.
Carding Process						
Roller and Clearer Cards						
7	..	$3\frac{1}{2}$	C	Hard waste with proportion of bobbin waste.	On front of a working roller and clearer card.	Most of dirt is mineral; large proportion of fine particles are fixed in oil droplets; very little husk.
8	..	..	G	Waste.	On doffer cover of a breaker card.	Some cotton hairs, mineral dust, and fragments.
Stripping Process						
9	1	4	F	Good American.		

	9	1	4	F	Good American.	Near doffer of revolving flat card, vacuum exhaust hood on brush.	Very little dust; a few small cotton hairs and some finer fragments; a few mineral particles reaching 40μ.
	10	1	6	F	Same as for sample 9.	Near cylinder of revolving flat card; exhaust as in sample 9.	More dense than sample 9; particles of same character.
	11	2	10	H	Good mid American.	One volume each doffer and cylinder with closely applied exhaust hood.	Not dense; a few cotton hairs; some husk and finer particles.
	12	2	14	H	Same as for sample 11.	Same as sample 11 but with duct of exhaust hood closed.	Not strikingly different from sample 11.
	13	2	?	C	Broken hard waste.	One volume each cylinder and doffer during hand stripping without exhaust.	A large quantity of débris consisting of short cotton hairs, husk, and mineral particles up to 0.1 mm.—very dirty process.
	14	1	15	D	Low American (A. S.) and waste.	At stripping by power brush with exhaust not directly applied to brush.	Amount of dust very much less than half of that in sample 13; consisting of a few cotton fibers and small particles of husk and mineral; occasional particles of mineral reach 0.06 mm.
	15	1	4	G	Waste.	Over cylinder of finisher card; exhaust on cover.	Much dust; chiefly of fine size; small fragments of cotton and mineral particles ranging down to about 2μ; perhaps most of particles are vegetable.
					Grinding Process		
					Revolving Flat Card		
	16	..	5	A	Low Egyptian.	In south end of card room on revolving flat card during grinding.	Much mineral matter, fine particles distributed commonly in groups, probably in oil droplets.
					Roller and Clearer Cards		
	17	3	12	G	Waste.	At grinding finisher card; first volume taken immediately after stripping.	Much dust, chiefly cotton hairs and fragments of husk, etc.; mineral particles vary in size from 2μ to 60μ.

TABLE 2.—*Continued*

NO. OF SAMPLE	VOLUME	TIME (*minutes*)	FACTORY	COTTON	SOURCE OF SAMPLE	RECORD
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Grinding Process—*Continued*			
18	3	10	J	Low waste; Indian fly and drop.	At grinding roller and clearer card without exhaust.	Considerable amount of long cotton hairs; mineral particles numerous up to 100μ, probably abrasive.
19	3	10	J	Same as for sample 18.	At grinding as in sample 18, but with exhaust.[1]	Very few cotton fibers; abrasive particles fairly numerous up to 100μ or more.[1]
			Mixing Room			
20	..	5	E	Sea Island.	Under new improved hopper bale breaker machine in order to catch coarse husk, etc., falling through bottom.	Chiefly portions of husk up to 0.75 mm.; mineral is mostly smooth sand particles up to 0.1 mm.[2]

[1] The notable difference between samples 18 and 19 is the absence of cotton from 19 so that the effect of exhaust seems to be the removal of particles of low specific gravity or relatively large surface.

[2] No obvious dust escaping into atmosphere. Much coarser matter falling from the machine than is retained by the record.

by strong suction, closely applied to the face of the card) (see sample 20) a count is given of the same order as for the general air of the same card room (see sample 4), indicating that there is no substantial increase in the atmospheric dust by this process, and that the general air current is from the room to the duct. Stripping with the brush, even when this is fitted with a vacuum exhaust, liberates much dust into the atmosphere (sample 21). The same effect is found in stripping roller and clearer cards by hand, in sample 23, though the count is much less in sample 26.

Grinding.—The samples were taken with the instrument close to the grinding roller in each case, so that the counts represent the atmosphere at that point rather than at the breathing level of the worker. The grinding process is automatic to a great extent and does not necessitate the continuous presence of the grinder. Considering the intermittent exposure of the worker, and the relatively low counts of particles of abrasive under 2 microns in size, the hazard of dust inhalation to which strippers and grinders are exposed cannot be said to constitute a substantial danger to health, in so far as the abrasive is concerned. In all probability the other kinds of dust are more capable of producing injury.

Settlement Dust Counter

The samples taken with this instrument are described in Table 2. The instrument has been used in some of the experiments as a volumetric test, in others as a time exposure test. In the volumetric tests, the cubic content of air represented by 1 volume (column 2) is 7.854 c.c. In the other tests, a circular plate 1 cm. in diameter, with a surface covered with an adhesive, was exposed for the time indicated in column 3. The records have not been counted in any of this series of samples, since the more accurate method of the Owens jet dust counter was available. The records show, however, the character of particles too large to pass the jet orifice of the Owens instrument. The results obtained by the two methods are in general agreement.

Conclusions

Any deductions drawn from the data submitted in this report have only a relative value, absolute comparisons being impossible, owing to the variety of important disturbing factors to which reference has already been made. The dust to which strippers and grinders are exposed has been collected from a variety of sources, and no special constituent of this dust has been discovered which is known to exert a specific action on the respiratory organs. The cause of the disability produced among these workers must, therefore, be a matter of conjecture until further special investigations can be carried out. The constituents of the dust are emery, cotton hairs, other parts of cotton, mold fungus (mycelium, conidia, and spores); and extraneous mineral matter.

Emery is not present in the atmosphere in such quantity or in such a fine state of division as to constitute an obvious danger to health; the fact that continuous close application of the worker is not practised removes, still further, the risk of danger from this constituent.

Cotton hairs and other parts of cotton are present in excessive quantity in certain of the stripping processes, and breathing the atmosphere charged with these particles produces discomfort in a person unaccustomed to the dust. It is probable that this dust, in excessive quantity, is capable of producing changes in the lungs after a long period of exposure; the nature of this change would be toward chronic bronchitis.

Mold fungus, present in the form of conidia and spores, has presented an interesting problem in another phase of cotton manufacture with regard to its possible action in the causation of respiratory disease. There is no doubt that cotton commonly harbors mold fungi which are capable of producing symptoms involving the respiratory system, though there is no definite evidence, at present, that any substantial incapacity is produced in this way. It may be that the chronic progressive symptoms of disease which lead to disability among strippers and grinders of carding machines are due to the action of mold fungi, acting either directly or indirectly, and dependent or not on a concomitant action of other constituents of the dust. The subject seems to be of sufficient importance to the industry to merit extended investigation.

Extraneous mineral matter is present in all the samples, but an examination of the physical characters of this constituent of the dust does not suggest that it alone forms a source of substantial danger.

THE PRESENCE OF MINERAL OIL IN THE ATMOSPHERE OF COTTON SPINNING ROOMS*

E. L. Middleton, M.D.

H. M. Medical Inspector of Factories

IN THE course of an investigation into the microscopic characters of dust in cotton carding rooms, the presence of minute droplets of oil was observed on the records of the atmospheric dust. From this observation the inference was drawn that oil, in a fine state of division, may exist in the atmosphere of mule spinning rooms, and the investigation now to be described was undertaken, at the request of the Mule Spinners' Cancer Committee, to elucidate this point.

Four mills were visited in September, 1925, and samples were taken with Owens jet dust counter in the mule rooms and, as a control, in the card rooms of three of the mills. As a further control, samples were taken at a mill where only ring spinning is carried on.

A word of explanation with regard to the instrument is necessary. The Owens jet dust counter is devised for the collection of fine particles of solid matter from the atmosphere, in such a way as to permit of subsequent examination and enumeration under the microscope. The principle by which the particles are made to adhere to the glass slide on which they are collected depends on the damping of the particles by the insertion of wet blotting paper in the collecting chamber, the effect of this procedure being to cover each particle with a pellicle of moisture which evaporates after it reaches the plate. The writer, regarding the collection of oil as not involving the damping principle and desiring to avoid any complications with dust, omitted the wet blotting paper from the instrument while taking the first eight samples. The result was entirely satisfactory with regard to the production of a clear record of oil droplets, with very little dust, but considerable difficulty was experienced in finding so inconspicuous a record; for the remaining six samples the damping method was therefore used.

The results of the examination of the records of samples taken are given in Table 1. The dimensions of the droplets refer to the surface covered on the slide; the actual diameter of the droplet in suspension in the atmosphere would, of course, be much smaller. It is evident that these droplets are not mere splashes, but that they will behave as fine particles and remain suspended in the atmosphere. There seems to be no ready method of proving beyond doubt that these droplets consist of a fixed oil. The only other liquid which suggests itself is water,

* Received for publication April 22, 1926.

TABLE 1.—SHOWING DATA FROM SAMPLES OF MINERAL OIL TAKEN WITH OWENS' JET DUST COUNTER

NO. OF SAMPLE	MILL	SOURCE OF SAMPLE	RECORD	COUNT (*droplets in 1 c.c. of air*)
1	A	Mule spinning room, near open door of carriage of mule no. 6.	.....	68; majority about 3μ, varying from 2 to 10μ.
2	A	Same as for sample 1, at breathing level, with all carriage doors closed.	.....	42; all under 5μ except 1 larger and of irregular shape owing to coalescence.
3	A	Card room, at breathing level, between roving frames.	.....	10; up to 10μ.
4	B	Lower spinning room, near carriage of mule no. 2 with 1 carriage door open.	.....	13; majority about 2 to 3μ, 1 of 10μ.
5	B	Same as for sample 4, at breathing level, with all carriage doors closed.	.....	12; majority under 5μ.
6	B	Card room, at breathing level, between roving frames.	Not distinguishable; whole slide covered with fine droplets,[1] averaging 20 over area 0.19 mm. square.	Majority 3 to 5μ.
7	C	Top ring spinning room, 3 ft. from floor.	No trace found.	.....
8	C	Same room as for sample 7, between frames near wall fan.	Very scanty; some droplets scattered over slide.	1; majority about 6μ.
9[2]	D	Lower mule spinning room, at level of mule carriage with all its doors closed.	.....	37; largest, 8μ.
10	D	Middle mule spinning room, at level of mule carriage with all its doors closed.	Very little oil; droplets sparse in other parts of slide.	4; largest, 8μ.
11	D	Same room as for sample 10, at level of mule carriage (1 section of mule oiled 5 min. before taking sample) with all its doors closed.	.....	38; majority about 5μ, 1 of 100μ.

[1] These must have fallen on the slide during the few minutes of exposure to the air of the card room.

[2] The use of the damping chambers in this and subsequent samples is followed by the collection of much more dust than in samples 1 to 8. Some of the droplets contain a minute solid particle; a few larger particles or masses of dust are surrounded closely by a film of oil; many droplets, however, are free from visible particles, and many particles are not surrounded by oil.

TABLE 1.—*Continued*

NO. OF SAMPLE	MILL	SOURCE OF SAMPLE	RECORD	COUNT (*droplets in 1 c.c. of air*)
12	E	Mule spinning room no. 1, close to mule carriage with all its doors closed.	Very little oil.	2; majority 4 to 10μ, 1 of 20μ.
13	E	Same room as for sample 12, at breathing level in window space.	Very little oil.	1 to 2; majority about 5μ, a few up to 20μ.
14	E	Card room, at breathing level, between roving frames.	Scanty oil; more numerous and smaller droplets on other parts of slide.[3]	2; from 8 to 20μ.

[3] It is possible that the dust particles on the record took up or obscured the smaller droplets in their vicinity.

but this is scarcely possible, for the water of condensation rapidly evaporates from records taken with the damping chamber, and crystals are often found when soluble salts have been present in the atmosphere. That these droplets are not usually present in the atmosphere, and that this appearance of droplets is not commonly found in dust records, can be stated with the force of experience acquired from the examination of several hundreds of samples taken from many different sources.

If it is assumed that these droplets consist of oil, and the evidence is in support of this view, the results enumerated in Table 1 seem to indicate that the amount of oil present in the atmosphere in this very fine state of division is greater in the mule spinning rooms than in the carding rooms of the same factories and in the spinning room of a ring spinning factory.

The samples taken with the door of the mule carriage open gave higher counts than the corresponding samples with the doors closed, and a sample taken near recently oiled spindles gave a count of 38 droplets in 1 c.c. as compared with a sample, taken from the same place after an interval of two hours from the last oiling, which gave an almost negligible count of 4. These results point to the origin of some of the oil droplets.

The significance of the presence of the oil droplets lies in the fact that here is a possible explanation of the access of oil to parts of the skin which are neither exposed to oily surfaces, such as machinery, nor in contact with saturated clothing. Whether or not the amount of oil which can gain access to the skin from the atmosphere is sufficient to determine the occurrence of a lesion, it seems possible that a cumulative action may be produced, even by minute quantities, on such skin structures as present a low surface tension to oil.

BOOK REVIEW

METHODS OF INVESTIGATING VENTILATION AND ITS EFFECTS. By *H. M. Vernon and Others.* Med. Res. Council, Special Rep. Series No. 100, pp. 71. London: H. M. Stationery Office, 1926.

This report is concerned with ventilation problems of interest to both the hygienist and the engineer. It is divided into four parts, each of which is well illustrated by photographs and charts and concludes with a brief list of pertinent references.

Part I. The Measurements of Variations in the Velocity and Temperature of Air Currents

H. M. Vernon and J. J. Manley

The authors state that "in workrooms the air currents move not only horizontally, but to no inconsiderable extent in a vertical direction." A hot wire anemometer was designed to measure these currents or "rapid oscillations of air velocity." It consisted of three platinum wires in three planes at right angles. The wires formed part of a Wheatstone bridge, and a 0.5 ampere current heated them to about 130°C. The changes of resistance produced by variations in the velocity of the air currents were indicated by a galvanometer, which was read at intervals of $2\frac{1}{2}$ seconds. The apparatus was calibrated by comparing it against a kata-thermometer in a small wind tunnel.

"In order to measure rapid oscillations of air temperature, a thermopile consisting of 20 iron-nickel junctions was designed. The wires were fixed to a wooden ring, and the upper junctions were hammered very thin, whilst the lower ones were protected by an annular trough of brass (or wood). The thermopile was connected to a dead-beat galvanometer. It was calibrated by dipping it into water at different temperatures, and by taking it from one room to another of a different temperature.

"Control observations showed that the thermopile was unaffected by changes of air velocity, though rapidly responsive to changes of air temperature, whilst the hot-wire anemometer showed the reverse response."

The control observations and calibrations are all given with both anemometer and thermopile arrangement described in sufficient detail so that anyone interested can duplicate Dr. Vernon's instruments or check his results.

Part II. The Calibration of the Kata-Thermometer

H. M. Vernon

In this section the author describes investigations into the accuracy of the dry kata-thermometer for measuring low velocity air currents in both horizontal and vertical directions. "The low velocity observations were made by the 'whirling arm' method, at an average temperature of 57°F., whilst those at velocities over a metre per second were made.

chiefly in wind tunnels, at an average temperature of 67°."

The author summarizes this chapter as follows:

> The "factor" of the kata-thermometer is not constant. Observations made on three katas in two forms of chamber showed that it varied by ±0.34 per cent. for each degree above or below 57°F.
>
> Owing to the variability of the factor and to a less extent to other reasons, the relationship between the H/θ values and air velocity is considerably affected by temperature. The temperature correction which has to be applied to the ascertained H/θ is smaller and smaller the greater its magnitude, for it ranges from 0.44 per cent. per °F. with an H/θ of 0.27 to one of 0.10 per cent. with an H/θ of 0.60 and upwards. A table of equivalents between H/θ and air velocity at various temperatures has been constructed.
>
> By means of a small wind tunnel, which could be fixed vertically as well as horizontally, the response of the kata and the hot-wire anemometer to vertical air currents was tested. The kata is quite unreliable for measuring descending currents, for with an air velocity of 300 ft. per min. it indicates only a third the theoretical, and at lower velocities it gets more and more inaccurate, till at very low velocities it gave an H/θ of 0.24. The hot-wire anemometer indicates about two-thirds the theoretical velocity (as measured by vane anemometer).
>
> With slow ascending air currents the kata is moderately accurate, but at high velocities it indicates considerably lower values than the theoretical.

Part III. The Influence of Cooling Power and of Variability of Air Currents on Sensations of Air Movement

H. M. Vernon, T. Bedford, and C. G. Warner

Probably this and the subsequent section will be of most interest to those concerned with ventilation—particularly since Dr. Vernon criticizes, in no uncertain terms, the work of the Research Laboratory of the American Society of Heating and Ventilating Engineers on the development of their two effective temperature scales and their comfort zone applying to one of these scales.

Vernon claims that the Pittsburgh studies took no account of acclimatization and that the methods used and the conditions of the experiments were unnatural. His arguments are based on what appears to be a rather surprising lack of understanding of the Pittsburgh work. On page 33, line 15, referring to saturated air he mentions "combinations of effective temperature and air velocity." One of the advantages of the effective temperature scale is that it includes air velocity. He means, presumably, conditions of saturation with various air velocities which give the same effective temperature. That he has misunderstood this rather fundamental point in the effective temperature investigations is evident from his statement, three lines later, that "effective temperatures are likewise dry bulb temperatures" in five examples that he cites. To only one of his five does this apply. He implies (page 34) that in determining the two effective temperature scales the subjects passed back and forth between two rooms differing widely in conditions of temperature, humidity, and air motion. In some experiments the conditions in the two rooms varied widely—how else could widely differing conditions be compared?—but in the majority of the experiments the two rooms differed by only 2° or 3° dry bulb

temperature. This was especially true of all experiments at or near the region of the comfort zone.

On page 34 Vernon points out that in the establishment of the comfort zone for people normally clothed Houghten and Yaglou's results showed a higher optimum comfort line if this line were approached from high temperatures than if it were approached from low. The reader might infer that the Pittsburgh investigators were unaware of this. In their outline of the program for this particular investigation Houghten and Yaglou mention the following procedures, both of which were carried out (*Tr. Am. Soc. Heating and Ventil. Eng.*, 1923, vol. 29, pp. 361 and 362):

> 1. . . . . The lower and upper limits of the zone to be established by approaching them from both higher and lower temperatures so as to compensate for any possible effect of acclimatization.
>
> 2. Verification of the slope of the effective temperature lines in the comfort region by primary sense reactions of individuals wearing normal clothing.

On page 364, Figure 3, of this same article Houghten and Yaglou present the collected data from eight two-hour tests for determining the comfort zone. It is presumably from these data that Vernon concludes (page 34): "Reading off the temperatures recorded in one of their diagrams, we found that on an average the comfortable effective temperature was 64.6° when approached from the cold side, and 65.5°, or nearly 1° higher, when approached from the warm side."

Another matter of interest (not pointed out by Vernon) which a statistical analysis shows is that once the optimum comfort line was reached, the subjects were more sensitive to changes toward "too cool" than toward "too warm." This might well be due to increased insensible perspiration causing the subjects to be more sensitive to cooler than to warmer temperatures—an effect which certainly must be important in seasonal acclimatization. In the Pittsburgh experiments this effect might possibly have been reduced by making the experiments of much longer duration. As these were performed, the subjects did not pass through the entire zone in one experiment but only through either the upper or the lower portion.

The difference of "nearly 1°" (given by Vernon) between the two optimum lines (approaching from the cool and warm sides) Houghten and Yaglou reduced to about ½° by purposely combining the two curves. Admitting the possibility of a maximum error of ½°, is this impractical? Can anyone tell within ½° the temperature of a room he enters? Passing back and forth between two rooms ½° apart he may be able to judge which is warmer or cooler, but, if Vernon's objections are valid, then the average observer (not a trained subject) should be able to judge within ½° the temperature of a room he enters. Certainly Dr. Vernon would make no such claim.

Vernon's method of judging sensations of air movement was on the basis of an arbitrary scale of 8 units, number 8 being "very fresh" while number 1 was "very stagnant." Three observers made records of their sensations in twelve different factories giving in all 432 observations together with which kata determinations are included. Analyzing his results by

months and seasons he concludes (page 57):

> to produce a given sensation of air movement in winter required a cooling power about one unit higher than that required in summer. This was due to acclimatization, and the mean cooling power (in relation to a given sensation) was found to change gradually from month to month as the mean temperature changed.
>
> It was found that the various degrees of "stagnancy" experienced in factory air were due entirely to differences in the air temperature, whilst the various degrees of "freshness" were due chiefly to differences in air velocity. The cooling power of the kata-thermometer combines these two variables better than any other known measure, and the correlation ratio of cooling power on air sensation was found to be .703 in summer, and .790 in winter.

A comparison of these correlation ratios with those from the Pittsburgh studies on effective temperature and definite physiologic reactions (*Tr. Am. Soc. Heating and Ventil. Eng.*, 1923, vol. 29, p. 360) lends no support to Vernon's argument on the alleged superiority of the kata to the effective temperature scale as a method of judging sensations of comfort. The Pittsburgh correlation ratios were 0.975 for rectal temperature increases, 0.961 for pulse rate, and 0.88 for systolic pressure, all three being with reference to effective temperatures. His lower correlation ratios in summer as compared with winter indicate that evaporation and humidity, of which the kata takes no account, cannot be ignored. The effective temperature scale, on the other hand, does not ignore humidity and this Vernon points out clearly.

Vernon's data give very interesting and important information on fluctuating drafts, air currents, and seasonal acclimatization in England. Whether one agrees with all of this section or not it is well worth studying for the data he supplies.

Part IV. The Influence of Temperature, Air Velocity, and Clothing on the Rate of Cooling of the Human Body

H. M. Vernon

"The method of experiment adopted consisted in warming up the body to a convenient height by means of step climbing, and subsequently determining its rate of cooling. All the observations to be described were made by the writer on himself and at his home, where the conditions of experiment could be kept very steady." His experiments show that differences in clothing cause very appreciable differences in the rates at which the body cools after exercising. He calculates that the naked body will remain in temperature equilibrium at 81° to 83° and the warmly clothed body at 59° to 60°. The naked body estimates are in good agreement with the Pittsburgh results (see THIS JOUR., 1926, vol. 8, pp. 11 and 12) but 59° to 60° for the warmly clothed body is a lower zone than was found in the Pittsburgh studies. This may be due to the fact that "warm clothing" in Great Britain probably means woolen underwear, a woolen suit, and woolen socks. In the Pittsburgh studies "heavy clothing" meant the clothing habitually worn by outdoor laborers in winter and early spring in districts like Pittsburgh. The average American man or woman spending most of his or her day indoors wears very much lighter clothing all year round than does the

Britisher; furthermore very few Americans wear woolen underwear or heavy suits indoors at any season of the year. The Scotch proverb, "Ne'er cast a clout till May is out," does not apply in America! Reporting on a portion of the Pittsburgh work Yaglou and Miller (*Tr. Am. Soc. Heating and Ventil. Eng.*, 1925, vol. 31, p. 99) state: "Thus it is left to the judgment of the heating and ventilating engineer to shift the comfort line back or forth according to seasonal variations in the clothing worn. If lighter clothing is worn in summer than in winter, the comfort line will approach the lower boundary of the zone in winter and the upper boundary in summer." In other words because of climatic conditions Americans emphasize indoor temperatures and dress accordingly, particularly in winter, while in Great Britain one dresses more according to outdoor than indoor conditions.

It would be well to remember that no international or interracial claims for the validity of the American comfort zone have been advanced. It is intended for "average Americans" accustomed to the vicissitudes of American winter climates, methods of living, and heating standards. The effective temperature scales, on the other hand, should apply in England as well as in America; but whether they can be applied interracially has not been determined.

The comfort zone investigations at Pittsburgh were carried out during the months of March, April, and May. In the reviewer's opinion they took due account of diurnal acclimatization and of average differences in clothing, but ignored seasonal acclimatization for the reason that the American ventilating engineer is concerned with spring and fall and winter conditions rather than with those of summer. The methods used possessed the advantage of accuracy and very exact control but the disadvantage of artificiality. At the same time indoor climates in the northern parts of America, if climate is the proper word, are distinctly artificial and particularly so in winter. In Great Britain there is a much smaller yearly temperature variation, in both wet and dry bulb, than in the colder parts of the United States and in Canada. It may be proper in England to show indoor seasonal acclimatization effects by means of the kata, which takes no account of wet bulb temperatures, but in the greater portion of the United States and of Canada this is a questionable procedure.—*Philip Drinker.*